Interaction Between Nutrition and Reproduction in Dairy Cows

Amin Ahmadzadeh

Animal and Veterinary Science Department
University of Idaho

- “Homeorhesis” is orchestrated changes in metabolism of body tissue required to sustain a specific physiological status.

- BAUMAN AND CURRIE
**Metabolic Changes Following Parturition**

- Fat tissue metabolism changes from nutrient uptake to lipid mobilization.

- Glucose utilization shifts to the mammary gland from the reproductive tract.

- Up to 1/4 of the total body protein can be mobilized for the benefit of the mammary gland.

- **Basically, in high producing cows the mammary gland takes priority over the reproductive system**

  (Swanson, 1989)

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**Role of Energy Balance on Reproduction**

- In high producing cows, increased nutrient needs required to satisfy milk production cannot be adequately met by the postpartum diet mainly due to low feed intake.

- When feed intake does not meet the nutrient requirements of increased milk production, negative energy balance occurs.
Hypothalamic-pituitary-ovarian Axis
Recovery Following Parturition

- 1) Recovery from the exposure to high placental hormones
- 2) Overcoming lactation-induced inhibitor of gonadotropins
- 3) Initiation of luteal development
- 4) Occurrence of estrus and pregnancy

What Is Happening?

High producing dairy cows
\[\downarrow\]
Low feed intake
\[\downarrow\]
Negative energy balance
\[\downarrow\]
Excessive mobilization of body reserves
\[\downarrow\]
Body condition loss
\[\downarrow\]
Fatty liver syndrome
\[\downarrow\]
Reproductive inefficiency

via several possible mechanisms
Postpartum Body Condition Loss and Reproductive Performance

- Dairy cows in negative energy balance lose body weight because body reserves are mobilized as energy sources to support lactation.

- The severity of postpartum negative energy balance and the delay in the initiation of reproductive cyclicity is associated with body weight and body condition loss.

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Table 3. Relationship between body condition changes during the first 5 weeks postpartum and reproductive performance.

<table>
<thead>
<tr>
<th>Trait</th>
<th>High body condition</th>
<th>Low body condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>No cows</td>
<td>46</td>
<td>30</td>
</tr>
<tr>
<td>Body condition score change (week 1-5)</td>
<td>+.06</td>
<td>-.58</td>
</tr>
<tr>
<td>Days postpartum to ovulation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>First</td>
<td>17.2</td>
<td>23.3</td>
</tr>
<tr>
<td>Second</td>
<td>35.8</td>
<td>44.3</td>
</tr>
<tr>
<td>Conception rate, %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>First service</td>
<td>62</td>
<td>25%</td>
</tr>
<tr>
<td>All services</td>
<td>61</td>
<td>42%</td>
</tr>
</tbody>
</table>

1 body score changes from the average for the entire group

Britt, 1992
Mechanisms of Action (Summary)

- negative energy balance
  - low insulin and IGF and high NEFA
    - altered LH secretion
      - impaired follicular development
        - delayed ovulation
    - embryo survival
  - altered progesterone secretion
    - expression of heat

Feeding Strategies in Early Postpartum to Minimize Negative Energy Balance and Loss of Body Condition

- Maximizing energy density of the diet
  - increasing nonstructural carbohydrate (e.g. high moisture corn) in the diet
  - supplementing fat (e.g. whole cotton seed or by pass fat)
Feeding strategies cont.

• Fat supplementation to increase density of dietary energy
  – **Advantage**: may improve fertility by increasing plasma concentration of cholesterol and thus progesterone synthesis
  
  – **Disadvantage**: cannot be fed in high amount and rumen inert fat is relatively expensive

Other Things We Can Do

• Adjustment of the diet of dry cows during the late dry period so that dry cows do not lose too much body condition

• Body condition score of 3.25-3.75 at calving seems to perform better in terms of metabolic and reproductive health

• Feeding high quality and fresh feed several times a day stimulates feed intake and improves energy status
Common Practice

- Dairy producers try to maximize feed intake during early postpartum for higher milk peak.

- High protein rations are generally more palatable and stimulate intake.

- Dairy producers may feed crude protein in excess of requirement.

Role of Protein on Reproduction

- Increasing dietary crude protein, may lower fertility by increasing days to first postpartum ovulation, service per conception, and (or) days open.

- Does excess dietary crude protein influence reproduction?
Table 1. Impact of feeding 18% versus 20% crude protein (dry matter basis) on estimated reproductive efficiency of dairy cows.

<table>
<thead>
<tr>
<th></th>
<th>Crude Protein dry matter, %</th>
<th>18</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rumen degradable protein/CP, %</td>
<td>60</td>
<td>70</td>
<td></td>
</tr>
<tr>
<td>Rumen undegradable protein/CP, %</td>
<td>40</td>
<td>30</td>
<td></td>
</tr>
</tbody>
</table>

**Predicted probability of pregnancy**

<table>
<thead>
<tr>
<th></th>
<th>Lactation 1 to 3</th>
<th>60%</th>
<th>61%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4th lactation and older</td>
<td>60%</td>
<td>43%</td>
</tr>
</tbody>
</table>

**Impact on fertility**

<table>
<thead>
<tr>
<th></th>
<th>Increased services</th>
<th>0</th>
<th>.65</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative risk of problem breeding</td>
<td>1.0</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td>Increased days open</td>
<td>0</td>
<td>10-15</td>
<td></td>
</tr>
</tbody>
</table>

**Cost, $**

<table>
<thead>
<tr>
<th></th>
<th>Days open, $2/day</th>
<th>0</th>
<th>20-30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein, extra amount for 120 days of lactation</td>
<td>0</td>
<td>25</td>
<td></td>
</tr>
</tbody>
</table>

**Mechanisms of Action**

- Feeding excess RDP can lead to elevated ammonia and blood urea.

- High ammonia may delay clearance of uterine contaminants by reducing the immune system function.
Mechanisms of Action cont.

- High blood urea concentration may alter uterine pH, prostaglandin and/or progesterone production resulting in an undesirable uterine environment for embryo survival.

- Ammonia and urea may impair sperm, egg, or early embryo survival.

- Imbalance in protein:energy ratio may negatively affect metabolism

- Nitrogen byproducts and (or) efficiency of energy utilization may alter gonadotropin and progesterone secretion

Excess dietary protein & high rumen degradable protein

Milk urea nitrogen ~ 21 mg/dl

Blood urea >25 mg/dl?

Liver

Urea

Ammonia

via Blood & Saliva

Rumen

† Protein

† Peptides and Amino Acids

† Ammonia
Table 2. Relationship between crude protein (CP) level, conception rate and blood urea nitrogen (BUN).

<table>
<thead>
<tr>
<th>Reference</th>
<th>15-16 % CP</th>
<th></th>
<th>19-21 % CP</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Conception</td>
<td>BUN (mg/dl)</td>
<td>Conception</td>
<td>BUN (mg/dl)</td>
</tr>
<tr>
<td>Jordan &amp; Swanson</td>
<td>53</td>
<td>NR</td>
<td>40</td>
<td>NR</td>
</tr>
<tr>
<td>Folman et al.</td>
<td>56</td>
<td>8.8</td>
<td>44</td>
<td>15.4</td>
</tr>
<tr>
<td>Kaim et al.</td>
<td>57</td>
<td>9.0</td>
<td>43</td>
<td>17.0</td>
</tr>
<tr>
<td>Howard et al.</td>
<td>87</td>
<td>15.0</td>
<td>85</td>
<td>26.0</td>
</tr>
<tr>
<td>Carrol et al.</td>
<td>64</td>
<td>11.0</td>
<td>56</td>
<td>24.0</td>
</tr>
<tr>
<td>Bruckental et al.</td>
<td>65</td>
<td>25.0</td>
<td>52</td>
<td>32.0</td>
</tr>
<tr>
<td>Canfield et al.</td>
<td>48</td>
<td>12.0</td>
<td>31</td>
<td>19.0</td>
</tr>
<tr>
<td>Elrod and Butler</td>
<td>83</td>
<td>&lt;16.0</td>
<td>62</td>
<td>&gt;16.0</td>
</tr>
<tr>
<td><strong>Avg.</strong></td>
<td><strong>62</strong></td>
<td><strong>13.8</strong></td>
<td><strong>48</strong></td>
<td><strong>21.3</strong></td>
</tr>
</tbody>
</table>

- 24 Holstein herds in Ohio:
  - cows with MUN values above 15.4 mg/dl were 1.4 times less likely to be confirmed pregnant than cows with lower MUN levels (12.7 mg/dL)
Impact of Excess Protein on Reproduction (Summary)

excess rumen degradable protein

↓

elevated ammonia, blood and tissue urea, low uterine pH

delay clearance of uterine contaminants

AGE & Energy Status

possible detrimental effects on sperm, egg, and embryo survival

alteration on gonadotropin and progesterone secretion

Deficiency in metabolism

Management Aspects

• MUN concentration between 10-16 mg/dL is an acceptable range.

• Samples for MUN testing should be taken from group of cows that are in same plane of diet and are in a similar stage of lactation.

• Bulk tank MUN is not informative:
  – By only taking a bulk tank sample we would not be able to detect a problem within a group of cows that experience deficiency or excess of dietary protein.
Management Aspects

• How many cows should we test?
  – if samples are collected only for milk urea, it is possible to sample a minimum of 8-10 cows in a group.
  – reasonable number of cattle to test is 15 to 20% of the group.

• Reduce variation and confounding effects
  – initial and subsequent samples should be taken at the same time of the day.
  – Consider feeding and milking time

Suggestions

• Rations should be formulated to provide proper amount of rumen degradable and rumen undegradable protein
  – Balance for 18% crude protein DM for high producing cows
  – rumen degradable / rumen undegradable about 63% to 33%

• After critical evaluation of other aspects of reproductive management adding bypass protein may be considered